Journal of Pioneering Medical Sciences
Received: April 28, 2025 | Accepted: September 11, 2025 | Published: November 05, 2025
Volume 14, Issue 10, Pages 36-42

DOI https://doi.org/10.47310/jpms2025141005

Influence of Smoking on the Color Stability and Longevity of Restored Discolored Teeth with Dental Crowns: A Systematic Review

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Abstract **Background:** Smoking is a well-established risk factor affecting oral health, yet its specific influence on the color stability and longevity of dental crowns restoring discolored teeth remains under- investigated. This systematic review explores how various smoking modalities, including conventional cigarettes and electronic alternatives, impact restorative materials. **Objective:** To evaluate the influence of smoking on the color stability and longevity of dental crowns used in the restoration of discolored teeth. **Methods:** A systematic literature search was conducted across PubMed, ScienceDirect, the Cochrane Library and Google Scholar up to [6/1/2025]. Studies involving human participants or *in vitro* models that assessed the impact of smoking on dental crowns in terms of color change (ΔE) or longevity were included. Data were extracted and synthesized narratively due to heterogeneity. Quality assessment was conducted using the Cochrane Risk of Bias tool for randomized trials and the Newcastle-Ottawa Scale for observational studies. **Results:** Eight studies met the inclusion criteria, comprising primarily *in vitro* experiments with some observational data. Conventional cigarette smoke (CS) consistently caused clinically unacceptable discoloration (ΔE>3.3) in most tested materials, particularly resin composites. Ceramic materials, such as lithium disilicate and zirconia, demonstrated greater resistance to staining. Harm-reduction products like electronic cigarettes and heated tobacco products (HTPs) induced less discoloration, although effects varied by material type and surface finish. Longevity outcomes were indirectly associated with material degradation, surface roughness and plaque retention, all of which were exacerbated by smoking. **Conclusion:** Smoking significantly compromises the aesthetic and structural integrity of dental crowns, especially those made of resin-based materials. While newer crown materials and harm-reduction smoking alternatives may mitigate discoloration, smoking cessation remains the most effective strategy for maintaining restoration longevity and color stability.

Key Words Smoking, Dental Crowns, Color Stability, Longevity, Prosthodontics, Esthetic Dentistry, Restorative Materials

INTRODUCTION

The influence of smoking on the color stability and longevity of restored discolored teeth, particularly those fitted with dental crowns, is a significant area of interest in contemporary dentistry. Studies have consistently shown that smoking adversely affects oral health, including the health of the supporting tissues around dental restorations. Research has established that tobacco use is associated with increased inflammation in periodontal tissues, which can compromise the integrity of dental crowns. For example, smoking has

been linked to greater expressions of inflammatory markers, such as IL-1β and TNF-α, in patients experiencing peri-implantitis, which can diminish the longevity of dental restorations, including crowns [1]. This connection highlights the risk smokers face regarding the overall health of the surrounding tissues that can impact restoration longevity [2].

Additionally, the type of dental materials used can interact with the deleterious effects of smoking. While all-ceramic restorations offer superior aesthetics, they may be more susceptible to discoloration in smokers due to the porous nature of the material, which can facilitate the absorption of tobacco by- products and other stains [3]. Conversely, metal-ceramic crowns tend to show enhanced longevity and stability when appropriately managed under smoking conditions due to their inherent material properties [4]. The longevity of crowns also correlates with the effectiveness of the marginal fit and the overall construction technique employed, which may be influenced by the smoking habit of the patient. Poor-fitting crowns can lead to an accumulation of plaque and subsequent periodontal failures [5]. Smoking may exacerbate these conditions, necessitating more vigilant management in selecting crown restorations for patients with this habit. Furthermore, the relationship between smoking and psychological factors, such as oral health-related quality of life, cannot be overlooked. Smokers frequently report diminished satisfaction with their restorative dentistry outcomes, likely compounded by the visual aspects of discoloration and failing restorations [6]. Therefore, this systematic review aims to critically evaluate and synthesize the existing evidence on the influence of smoking including conventional cigarettes and electronic alternatives on the color stability and longevity of dental crowns used in the restoration of discolored teeth. The objective is to provide clinicians with evidence-based insights to guide material selection and patient management strategies in smokers requiring prosthetic rehabilitation.

METHODS

Study Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [7]. The primary objective was to evaluate the influence of smoking on the color stability and longevity of dental crowns used in the restoration of discolored teeth. The review process followed a predefined protocol that included a structured search strategy, defined eligibility criteria, a rigorous selection process and a systematic method for data extraction and analysis.

Eligibility Criteria

Studies were considered eligible if they investigated the impact of smoking on the performance of dental crowns in restoring discolored teeth. Included studies involved human subjects, with a focus on either current or former smokers. The outcomes of interest were color stability, assessed through either objective instrumentation or subjective evaluation and the longevity or survival rate of the crowns over time. Eligible study designs included clinical trials, cohort studies, case-control studies, cross-sectional studies and retrospective analyses. Only articles published in English were considered, with no restrictions placed on the year of publication. Studies were excluded if they were *in vitro* or animal studies, review articles, case reports, conference abstracts lacking full data or if they did not explicitly report outcomes related to both smoking and the performance of crown restorations.

Search Strategy

A comprehensive literature search was carried out across five major electronic databases: PubMed/MEDLINE, ScienceDirect, the Cochrane Library and Google Scholar. The search strategy incorporated both Medical Subject Headings (MeSH) and free-text keywords: “smoking,” “tobacco use,” “dental crowns,” “tooth discoloration,” “color stability,” “longevity,” and “survival rate.” The search was conducted up to [6/1/2025] and reference lists of the selected studies were manually screened to identify additional relevant publications that may not have been captured in the database search.

Study Selection Process

All retrieved records were imported into reference management software to facilitate the removal of duplicates. Two independent reviewers then screened the titles and abstracts of the remaining articles to assess relevance. Full-text versions of potentially eligible studies were reviewed to confirm inclusion. Any disagreements between the reviewers during the selection process were resolved through discussion and when necessary, a third reviewer was consulted to reach consensus (Figure 1).

Data Extraction

Data from the included studies were extracted using a standardized extraction form developed for this review. The information collected included the author(s), year of publication, study design, population characteristics, sample size, type of dental crown material used, patients’ smoking status and duration, methods used to evaluate color changes and crown longevity, follow-up period and the main outcomes. Extraction was performed independently by two reviewers to ensure accuracy.

Quality Assessment

The methodological quality and risk of bias of the included studies were assessed independently by two reviewers. Randomized controlled trials were evaluated using the Cochrane Risk of Bias tool, while observational studies were assessed using the Newcastle-Ottawa Scale (NOS). Each study was rated as having low, moderate or high risk of bias based on established criteria. Any disagreements in quality assessment were resolved through discussion or adjudication by a third reviewer.

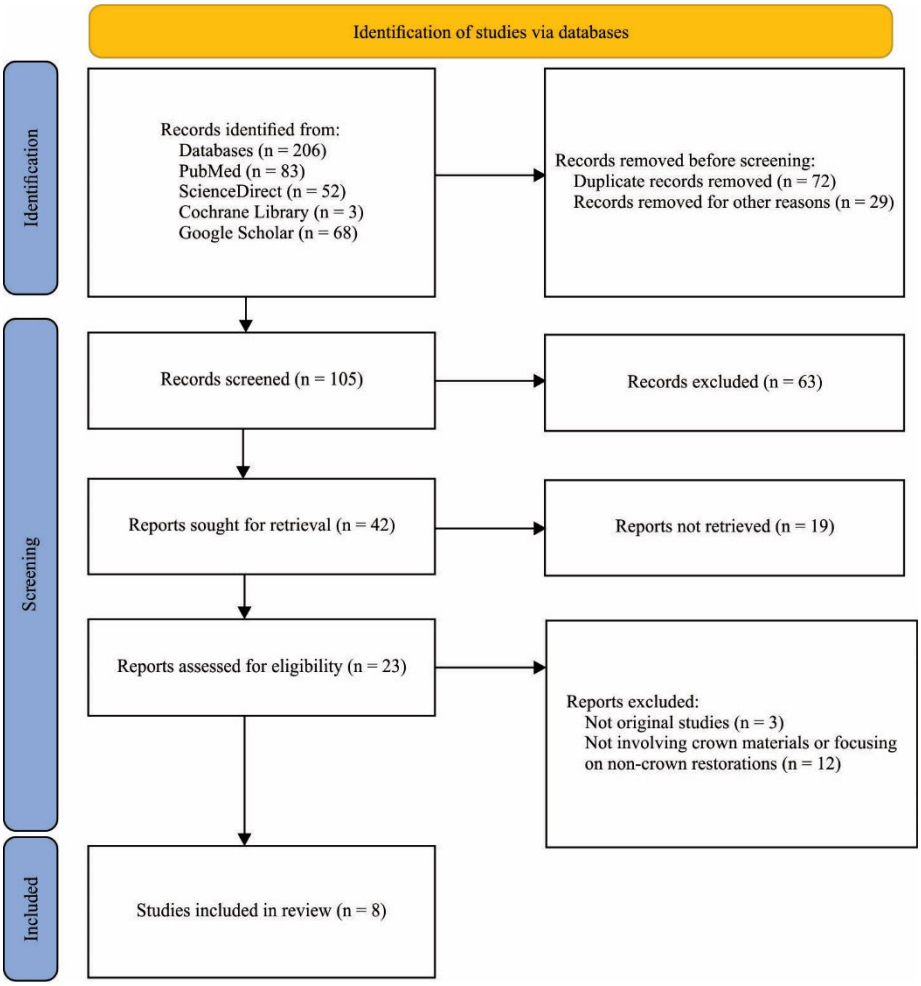
Identification of studies via databases
Identification
Records identified from:
Databases (n = 206)
PubMed (n = 83)
ScienceDirect (n = 52)
Cochrane Library (n = 3)
Google Scholar (n = 68)
Records removed before screening:
Duplicate records removed (n = 72)
Records removed for other reasons (n = 29)
Screening
Records screened (n = 105)
Records excluded (n = 63)
Reports sought for retrieval (n = 42)
Reports not retrieved (n = 19)
Reports assessed for eligibility (n = 23)
Reports excluded:
Not original studies (n = 3)
Not involving crown materials or focusing on non-crown restorations (n = 12)
Included
Studies included in review (n = 8)

Figure 1: PRISMA Flowchart Showing the Study Selection Process

Data Synthesis

A meta-analysis was not performed because of substantial methodological and outcome heterogeneity among the included studies, including differences in smoke-exposure protocols, assessment techniques and restorative materials.

RESULTS

A total of 206 records were identified through database searches, with 72 duplicates and 29 irrelevant records removed prior to screening. After title and abstract screening of 105 studies, 42 full-text articles were assessed for eligibility. Of these, 8 studies met the inclusion criteria and were included in the final analysis. The selected studies comprised primarily *in vitro* experiments, with one cross-sectional observational study [8]. These studies varied in terms of restorative materials tested, smoking exposure protocols and outcome measures. Due to the heterogeneity of methodologies and reporting formats, a narrative synthesis was conducted to summarize the key findings related to color stability and longevity of dental crowns in the context of smoking exposure. The characteristics and main findings of the eight included studies are summarized in Table 1.

The *in vitro* study by Alqahtani *et al.* [15] demonstrated that cigarette smoke significantly affects the color stability of dental ceramics, with all tested materials (lithium disilicate, zirconia and PFM) exhibiting clinically unacceptable discoloration ($\Delta E>3.3$). Pressable lithium disilicate (Emax) and porcelain-fused-to-metal (PFM) showed the least color change, while monolithic and layered zirconia were the most susceptible to staining. The study concluded that clinicians should prioritize materials like Emax for anterior restorations in smokers to mitigate aesthetic compromise, though the absence of oral environmental factors (e.g., saliva, abrasion) may limit direct clinical extrapolation. These findings underscore the need for patient counseling on smoking's detrimental effects on dental restorations. The *in vitro* study by Vohra *et al.* [12] compared the effects of Electronic Nicotine Delivery Systems (ENDS) and conventional cigarette smoke (CS) on Dental Ceramic (DC) and Resin Composite (RC). Results showed that both ENDS and CS caused comparable discoloration in RC ($\Delta E>40$, clinically unacceptable), while DC exhibited minimal color change ($\Delta E<2.5$, clinically acceptable). The study concluded that ENDS aerosol discolors dental restorations similarly to CS, with composites

Table 1. Summary of included studies evaluating the effect of smoking on the color stability and longevity of dental crown materials.

Author (Year)	Study Design	Materials Tested	Exposure Method	Key Outcomes	Main Findings	Limitations
Erdogan *et al.* [9]	*In vitro*	Gingiva-colored porcelain (GC Initial MC Gum) and composite resin (Gradia Plus)	Conventional (200 puffs) vs. e-cigarettes (200 puffs)	ΔE*ab, ΔE00, surface roughness (Ra, Sa)	Conventional cigarettes caused higher ΔE (porcelain: 7.404; composite: 9.708) vs. e-cigarettes (porcelain: 1.390; composite: 2.523). Roughness increased with conventional smoking (*p*<0.05).	No oral environment simulation (e.g., saliva, pH).
Alnasser *et al.* [10]	*In vitro*	Nano-hybrid (Filtek Z250 XT) vs. micro-hybrid (Filtek Z250)	Conventional (90 min) vs. e-cigarettes (90 min)	ΔE, translucency (TP)	Conventional smoking caused higher ΔE (nano: 1.74; micro: 0.85) vs. e-cigarettes (nano: 0.64; micro: 0.48). Micro-hybrid more color-stable (*p*<0.05).	Limited exposure duration; no mechanical wear simulation.
Makkeyah *et al.* [11]	*In vitro* experimental	Lithium disilicate (IPS e.max CAD), zirconia (BruxZir), PEEK (BioHPP)	600 cigarettes/Heets (30 days of medium smoking behavior, 20/day) using a custom smoking device	Surface roughness (Ra), color change (ΔE), SEM-EDX analysis	CS caused greater surface roughness and color change than HTP, Zirconia showed better color stability than PEEK, Glazed surfaces resisted roughness better than polished surfaces.	Limited to three materials, No brushing simulation, Short exposure duration.
Vohra *et al.* [12]	*In vitro* experimental	Dental ceramic (IPS Empress Esthetic), resin composite (Filtek Supreme Ultra)	7-day exposure to ENDS aerosol or CS (10 cycles/day, 10 puffs/cycle)	Color change (ΔE) using CIELAB system	ENDS and CS caused comparable discoloration in composites (ΔE>40, clinically unacceptable), Ceramics showed ΔE<2.5 (clinically acceptable), - No significant difference between ENDS and CS for ceramics.	Small sample size, Limited to one brand of ENDS, No thermocycling for composites
Zanetti *et al.* [13]	*In vitro* experimental	Human enamel, dentin and composite resin (Filtek Supreme Ultra)	3-week exposure to CS (3R4F) or THS 2.2 aerosol (20 sticks/day, 4 days/week)	Color change (ΔE), USPHS criteria for restoration quality	CS caused significant discoloration (enamel: ΔE = 8.8; dentin: ΔE = 21.3; composite: ΔE = 25.6), THS 2.2 caused minimal discoloration (ΔE<3.1), CS led to color mismatch between restorations and teeth.	Focused on THS 2.2 (a specific HTP), No clinical validation, Short-term exposure
Schelkopf *et al.* [14]	*In vitro* experimental	Lithium disilicate (IPS e.max CAD), zirconia (Wieland Zenostar), PMMA (Telio CAD)	10-day exposure to CS (Marlboro, 1 pack/day) using a custom smoking chamber; brushing simulation post-exposure	Color change (ΔE), L*a*b* values, perceptibility (ΔE = 1.2) and acceptability (ΔE = 2.7) thresholds	CS caused significant staining (ΔE>12.8-19.2), exceeding clinical acceptability, Brushing reduced staining but not to baseline levels, No difference in stainability between glazed/polished surfaces (LD/Zr), PMMA showed lower ΔE than ceramics post-smoking.	Heterogeneous smoke residue deposition, Single brand/materials tested, No thermocycling or other staining agents evaluated
Gupta *et al.* [8]	Cross-sectional	Natural teeth (current smokers, former smokers, never smokers, EC users, HTP users)	Digital spectrophotometry (CIE L*a*b, *WID, ΔE*)	Dental color parameters (whiteness, discoloration)	Current smokers had worse dental whiteness (13.38 WID) vs. never smokers (19.96 WID). EC/HTP users showed better color stability (16.72-17.82 WID).	Small sample size; cross-sectional design limits causal inference; residual confounding (e.g., diet).
Alqahtani *et al.* [15]	*In vitro* analysis	Pressable lithium disilicate (Emax), layered lithium disilicate (Lmax), porcelain fused to metal (PFM), monolithic zirconia (MZr), layered zirconia (LZr) in shades B1 and C1	Custom smoking chamber; exposure to conventional cigarette smoke (10 cigarettes/day) for 1 week, 1 month and 6 months	Color stability assessed using CIELAB (ΔE); statistical analysis (ANOVA, Tukey post-hoc)	All materials showed significant color change (ΔE>3.3). Emax and PFM exhibited the least discoloration, while zirconia (MZr, LZr) showed the highest.	In vitro design lacks oral environment simulation (saliva, brushing); no cleaning procedures evaluated.

being significantly more susceptible than ceramics. The study by Zanetti *et al.* [13] evaluated the impact of Cigarette Smoke (CS) and Tobacco Heating System (THS 2.2) aerosol on enamel, dentin and composite resin. CS caused severe discoloration (ΔE = 8.8-25.6) and color mismatch between restorations and natural teeth, whereas THS 2.2 resulted in negligible changes (ΔE<3.1). Brushing reduced staining but failed to fully restore baseline color after CS exposure. The authors concluded that THS 2.2 minimizes discoloration compared to CS, suggesting harm reduction potential for smokers. The study by Makkeyah *et al.* [11] assessed the effects of CS and Heated Tobacco Products (HTP) on CAD/CAM materials (lithium disilicate, zirconia, PEEK). CS induced greater surface roughness and color change (ΔE = 13.67-20.26) than HTP, with zirconia showing the best color stability. Glazed surfaces resisted roughness better than polished ones. The findings indicate that HTP causes less aesthetic degradation than CS and material choice (e.g., zirconia) can mitigate smoking-related discoloration. Schelkopf *et al.* [14] investigated CAD/CAM materials (lithium disilicate, zirconia, PMMA) exposed to CS. The study found significant staining (ΔE = 12.8-19.2) exceeding clinical acceptability thresholds. Brushing reduced staining but not to baseline levels. Surface finish (glazed vs. polished) had no significant effect on stainability. PMMA showed lower discoloration than ceramics. The authors concluded that smoking compromises restoration aesthetics, though oral hygiene can partially mitigate staining.

The study by Erdogan *et al.* [9] compared conventional and electronic cigarettes' effects on gingiva- colored porcelain and composite resin. Conventional cigarettes caused significantly higher discoloration (porcelain ΔE*ab = 7.404; composite ΔE*ab = 9.708) and increased surface roughness ($p<0.05$) compared to e-cigarettes (porcelain ΔE*ab = 1.390; composite ΔE*ab = 2.523). Porcelain showed better color stability than composite resin. The authors concluded that conventional smoking poses a greater risk to prosthetic materials' aesthetics, particularly for indirect composites. An *in vitro* analysis by Alnasser *et al.* [10] examined nano-hybrid and micro-hybrid composites exposed to conventional and e-cigarette smoke. Conventional smoking caused greater color shifts (nano-hybrid ΔE = 1.74; micro-hybrid ΔE = 0.85) and reduced translucency ($p<0.05$) compared to e-cigarettes. Micro-hybrid composites exhibited better color stability. The authors concluded that while e-cigarettes are less harmful, both smoke types affect aesthetics, with material composition playing a key role in stain resistance. Gupta *et al.* [8] observed that former smokers who switched to e-cigarettes or Heated Tobacco Products (HTPs) achieved dental whiteness levels (WID: 16.7-17.8) closer to never smokers (WID: 19.96) than current smokers (WID: 13.38), suggesting reduced staining with non- combustible alternatives. Collectively, these findings indicate that smoking accelerates dental material degradation, while modern fabrication methods (e.g., CAD/CAM) and harm-reduction products (e.g., HTPs) may mitigate discoloration risks. However, limitations such as *in vitro* designs and residual confounders warrant cautious interpretation. Across the included studies, zirconia consistently demonstrated the greatest resistance to smoking-induced discoloration, with ΔE values generally remaining below or near the clinical acceptability threshold even after prolonged exposure (e.g., Makkeyah *et al.* [11], ΔE≈13 for zirconia vs. ≈20 for PEEK; Alqahtani *et al.* [15], zirconia ΔE highest among ceramics but still lower surface roughness than resin-based materials). Lithium disilicate ranked second, exhibiting slightly higher color change than zirconia but superior esthetics compared with metal-ceramic options. In contrast, resin-based composites and PEEK materials showed the highest ΔE values and surface roughness, indicating the least color stability. These findings highlight a clear material hierarchy-zirconia>lithium disilicate>metal-ceramic>PEEK/composite-in terms of resistance to smoking-related discoloration and degradation.

DISCUSSION

The findings of this systematic review demonstrate that smoking significantly compromises both the color stability and longevity of dental crowns used to restore discolored teeth. The evidence consistently shows that conventional cigarette smoke causes clinically unacceptable discoloration (ΔE>3.3) across all restorative materials, with resin composites being particularly susceptible to staining (ΔE up to 25.6) [12,13]. This is attributed to the deposition of nicotine and tar on restorative surfaces, which alters their roughness and optical properties [16]. In contrast, electronic nicotine delivery systems (ENDS) and heated tobacco products (HTPs) induce less severe discoloration, particularly in ceramic materials (ΔE<2.5) [8,11]. These findings suggest that harm-reduction alternatives may mitigate some aesthetic risks for smokers requiring dental restorations.

Material selection emerges as a critical factor in managing smoking-related challenges. Zirconia and lithium disilicate crowns (e.g., IPS e.max) exhibit superior color stability compared to PEEK and PMMA, with monolithic zirconia showing the highest resistance to staining [14,15]. Metal-ceramic crowns, while less aesthetic, demonstrate enhanced longevity in smokers due to their mechanical robustness and marginal integrity [4]. However, the porous nature of all-ceramic materials may facilitate stain absorption in smokers, necessitating careful patient selection [3]. Surface finish also plays a role, as glazed ceramics resist roughness better than polished surfaces [11].

The longevity of dental crowns in smokers is further jeopardized by systemic and local factors. Smoking-induced inflammation (elevated IL-1β and TNF-α) compromises periodontal health, increasing the risk of peri-implantitis and marginal bone loss around crown-supported restorations [1,2]. Poor marginal fit exacerbates plaque accumulation and secondary caries, which are more prevalent in smokers [17].

These findings underscore the importance of precise fabrication techniques and regular maintenance in this patient population.

Similar findings have been reported by Jain *et al.* [18] who found that 3D-printed and milled provisional crowns exhibited superior resistance to cigarette smoke-induced discoloration and surface roughness compared to traditional PMMA and bis-acrylic resins. Similarly, Wasilewski *et al.* [19] reported that composite resins, especially translucent shades, underwent severe discoloration when exposed to cigarette smoke and alcohol, with combined exposure causing the most pronounced staining. Moreover, cigarette smoke has been reported to cause discoloration in resin composites [20,21] and dentures [22,23].

There were some limitations to our study. The predominance of *in vitro* studies limits direct clinical extrapolation, as oral environmental factors (e.g., saliva, pH, mechanical wear) were often omitted. There was substantial methodological and outcome heterogeneity across the included studies, including differences in smoking-exposure protocols (puff counts, durations, product types), restorative materials and ΔE thresholds. These variations precluded a quantitative meta-analysis and necessitated a narrative synthesis. Grey literature and clinical trial registries were not included, which may have introduced a degree of publication bias that should be considered when interpreting the findings. Future research should prioritize long-term clinical trials with standardized methodologies to validate these findings. Researchers should develop and adopt standardized smoking-exposure protocols covering puff frequency, duration and product type-to allow direct comparison across studies. Additional work is warranted to evaluate a broader range of restorative materials and surface treatments, including emerging CAD/CAM ceramics, hybrid composites and novel glazing or coating technologies.

CONCLUSIONS

This systematic review highlights the significant negative impact of smoking on the color stability and longevity of dental crowns used to restore discolored teeth. Conventional cigarette smoke consistently results in clinically unacceptable levels of discoloration, particularly in resin-based restorative materials, due to the accumulation of tar, nicotine and other by-products that alter surface properties. In contrast, ceramic materials such as lithium disilicate and zirconia exhibit greater resistance to staining, with glazed surfaces performing better than polished ones. Moreover, harm-reduction alternatives like electronic cigarettes and heated tobacco products show relatively lower staining potential, although they still affect restorative aesthetics to a lesser extent. For clinical practice, zirconia crowns should be prioritized for heavy smokers, followed closely by lithium disilicate when superior esthetics are desired, whereas resin-based or hybrid materials should be used with caution in patients who smoke. While appropriate material selection and meticulous surface finishing can mitigate some risks, smoking cessation remains the most effective strategy to preserve both the appearance and functional longevity of dental restorations. Future research should include long-term clinical trials employing standardized smoke-exposure protocols to validate these findings and refine evidence-based guidelines for prosthodontic treatment in smokers.

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